DISCRIMINATING AMONG ALTERNATIVE THEORIES OF THE MULTINATIONAL ENTERPRISE

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Revised draft: January 31, 2001

Abstract

Recent theoretical developments have incorporated endogenous multinational firms into the general-equilibrium model of trade. One simple taxonomy separates the theory into "vertical" models, in which firms geographically separate activities by stages of production, and "horizontal" models, in which multi-plant firms duplicate roughly the same activities in many countries. We refer to a hybrid of these two as the "knowledge-capital model". In this paper, we nest a horizontal and a vertical model within the (unrestricted) knowledge-capital model and estimate the specifications with data on U.S. foreign direct investment activity. In the nested econometric tests the data sample cannot distinguish statistically between the unrestricted model and the restricted horizontal model, indicating that the latter captures virtually all of the determinants of FDI. The tests overwhelmingly reject the vertical model.

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Introduction

While much of the industrial organization approach to trade theory makes little reference to multinational enterprises (MNEs), a number of papers published over the last 15 years have been successful in incorporating endogenous multinational firms into general-equilibrium trade models. As a consequence, we now have a reasonably well-developed set of theories that have implications about the relationships between MNE activity and such country characteristics as size and relative endowments.

One basic distinction in the theory is between "vertical" and "horizontal" firms. Vertical MNEs are firms that geographically fragment production into stages, typically on the basic of factor intensities, locating skilled-labor-intensive activities in skilled-labor-abundant countries and so forth. Early treatments of vertical investments include Helpman (1984), and Helpman and Krugman (1985). Horizontal MNEs are multi-plant firms that replicate roughly the same activities in many locations. Models of horizontal firms include Markusen (1984), Horstmann and Markusen (1987, 1992), and Markusen and Venables (1998, 2000).

These two strains of literature have been relatively disjoint, in large part due to technical difficulties. The early papers by Helpman and Helpman-Krugman assumed the absence of trade costs in order to produce analytical solutions. But under this assumption, there is no role for horizontal multi-plant firms driven by plant-level scale economies. Papers in the Horstmann-Markusen-Venables tradition typically assumed that there is only one factor used in the MNE sector, or that different activities (e.g., headquarters and plant) use factors in the same proportion. But under these assumptions, there is little motivation for fragmenting production by stages.

Recently there have been several attempts to integrate these models, allowing firms the options of building multiple plants or geographically separating headquarters from a single plant (Markusen, 1997). This approach is referred to as the "knowledge-capital model" because it assumes that knowledge is geographically mobile and a joint input to multiple production facilities.

Several empirical studies have estimated these models, although terminology differs among authors. Results in Brainard (1997, 1993) give support to the horizontal model but little support to the vertical model.[1] Several papers by Ekholm (1995a, 1997, 1998a,b) lend indirect support to the knowledge-capital model. More direct tests in Carr, Markusen, and Maskus (2001, hereafter CMM), and Markusen and Maskus (2001) strongly support the knowledge-capital model.

A difficulty with these studies, and indeed a chronic problem in empirical work more generally in the area, is that the authors posit no explicit alternative hypothesis to the model being estimated. Indeed, they are generally cautious about referring to "testing" the theory. The purpose of this paper is to perform such a test of the three models just mentioned: the knowledge-capital model (henceforth KK), the horizontal model (henceforth HOR) and the vertical model (henceforth VER). We develop the basic theory briefly, and note how each model offers predictions about foreign affiliate production of multinational firms as a function of characteristics of both the parent country and the host country. The HOR and VER models are then nested within an unrestricted KK model and estimated with extensive data involving U.S. foreign direct investment.

[1]Brainard uses the terminology “proximity-concentration” to mean essentially what we have in mind by “horizontal” motives for multinationals, and “factor proportions” for what we will refer to as “vertical” motives.

Results of this exercise indicate that in virtually all specifications the HOR model cannot be statistically distinguished from the unrestricted KK model in our data sample. Put another way, we cannot reject the HOR model as fully descriptive of FDI determinants. Econometric tests decisively reject the vertical model (VER). These formal results accord well with casual empiricism. The overwhelming proportion of world direct investment is from high-income developed countries to other similar high-income developed countries. This suggests that horizontal investment is much more important in the world economy than vertical investment, or at least vertical investments motivated by factor-endowment differences.

Before proceeding, we wish to emphasize our belief that vertical motives for direct investment may indeed be important in some industries and for some host countries. Our attempt in this paper is to run a "horse race" on aggregate data to determine which single model best reflects the data. Alternatively, we are seeking to find the dominant empirical motive for direct investment, without implying that more minor motives are absent. We find that the VER model is a poor specification for capturing the dominant motives for direct investment, and that the HOR model fits well, in our data sample. These results are closely consistent with those of Brainard (1993, 1997), CMM (2001), and Markusen and Maskus (2001).

2. Theory

Consider the following simple two-good, two-factor, two-country general-equilibrium model, relying on several assumptions.

(1) There are two homogeneous goods, labeled X and Y.

(2) There are two factors, skilled (S) and unskilled labor (L), that are immobile between countries.

(3) There are two countries, labeled h and f.

(4) Sector Y displays constant returns, perfect competition, and is L-intensive.

Sector X displays increasing returns to scale, is S-intensive, and its firms are Cournot competitors. X production requires a "headquarters" (fixed cost) activity and a production activity. An X firm may have one or two plants. There is free entry and exit within any of three X "firm types" defined as follows.

(a) Firm type-N is a single-plant national firm with headquarters and plant in the same country.

(b) Firm type-H is a two-plant horizontal firm with headquarters in one country and plants in both countries.

(c) Firm type-V is a single-plant vertical firms with headquarters and plant in different countries.

(6) There are transport costs in trading goods between markets and these costs use L.

(7) Markets are segmented.

In order to construct our different models of MNE activity in the X sector, we set out an options menu. Specifically, firms may be described by one or more of the following characteristics.

There are firm-level as well as plant-level scale economies.

Single plant firms may geographically separate plant and headquarters.

(c) Headquarters and plants have different factor intensities.

From this menu, we can specify the three models based on alternative assumptions. These are as follows, with mnemonics for identifying assumptions placed in parentheses.

<u>KK model</u>

(KK1) There are firm-level as well as plant-level scale economies.

(KK2) A single-plant firm may geographically separate headquarters and plant.

(KK3) Firm-level fixed costs are skilled-labor intensive relative to plant-level fixed costs and the marginal costs of production.

VER model

(VER1) There are no firm-level scale economies.[2]

(KK2) A single-plant firm may geographically separate headquarters and plant.

(KK3) Firm-level fixed costs are skilled-labor intensive relative to plant-level fixed costs and the marginal costs of production.

HOR model

(KK1) There are firm-level as well as plant-level scale economies.

(HOR2) A single-plant firm may not geographically separate headquarters and plant.

(HOR3) Firm-level fixed costs, plant-level fixed costs and the marginal costs of production all use factors in the same proportion.

While the VER and HOR models are fairly well known, a few comments are in order about the KK model. The KK model, as laid out in Markusen (1997) and CMM (2001) makes three principal assumptions.

(A) Transportability or fragmentation: the services of knowledge-based assets are easily supplied to geographically separate facilities.

(B) Factor intensity: knowledge capital is skilled-labor intensive relative to final production.

[2]Helpman does include firm-level scale economies in his 1984 paper, so this characterization of the vertical model should not be attributed to him. However, he concentrates on the case of zero trade costs, so there is no motive for horizontal firms to exist in equilibrium given plant-level scale economies. Thus, there are no horizontal firms *in equilibrium* in his model.

(C) Jointness: the services of knowledge-based assets are (at least partially) joint ("public") inputs into geographically separate production facilities.

Properties (A) and (B) create a motive for the vertical fragmentation of production. A firm's headquarters should be located in a country where skilled labor is cheap while a single production plant might be located in the other country. Property (C) implies the existence of firm-level scale economies and creates a motive for horizontal investments that replicate the same products or services in different locations.

What does theory tell us about the relationships between multinational activity and country characteristics? In the VER model with no firm-level scale economies and no motive for horizontal firms, multinational activity is driven entirely by differences in factor endowments. Type-V firms will be important when countries differ in relative endowments. To make the point directly, multinationals never exist between identical countries.

In the HOR model, we get largely the opposite result. MNEs will be most important between similar countries, provided that there are positive trade costs. MNEs will be less important as the countries differ in size or in relative endowments. The intuition here is that when countries differ significantly, one will be a "favored" location for placing headquarters of single-plant national firms, either because of a large domestic market (a type-H firm would have to locate costly capacity in a small market), or factor-price differences, or both.

In the KK model, MNEs can exist both when the countries are similar (type-H firms), or different (type-V firms) in relative endowments, particularly if the skilled-labor-abundant country is small. In the latter case, the headquarters would be located in the skilled-labor-abundant country. However, the plant would exist in the large, skilled-labor-scarce country, to take advantage of both the factor-price differences and the large market size. These results are summarized as follows.

KK model

(1) Both type-H and type-V multinationals can exist.

(2) Multinational are important when countries are similar in size and in relative endowments, and trade costs are moderate to high (type-H multinationals dominate).

(3) Multinationals are important when countries differ in relative endowments, particularly if the skilled-labor abundant country is small (type-V multinationals dominate).

VER model

(1) Only type-V multinationals can exist.

(2) Multinationals are important when countries differ in relative endowments.

(3) Multinationals do not arise between identical countries.

HOR model

(1) Only type-H multinationals can exist.

(2) Multinationals are important when countries are similar in size and in relative endowments, and trade costs are moderate to high.

To provide additional theoretical perspective, figures 1-6 depict simulation results for the three models.[3] The diagrams are the world Edgeworth box, with the world endowment of skilled labor on one axis of the base and unskilled labor on the other. The vertical axis measures the real volume of affiliate production by plants in country f of firms headquartered in country h (type H_h or V_h), and vice versa. This will prove to be the most useful representation of the theory, since available data contain figures on affiliate production and sales, but not on the numbers of firms (and certainly not by "type"). The endowment of country h is measured from the near, southwest corner (SW) and the endowment of country f from the far, northeast (NE) corner.

Figures 1-3 show total two-way affiliate activity, whereas Figures 4-6 show only the one-way activity of production by affiliates of country-h firms in country f. Relative to Figure 1, Figure 2 eliminates type-V firms and sets the factor intensities (S/L ratios) in fixed costs and variable costs the same for all X firms. Figure 2 thus gives the restricted HOR model. Relative to Figure 1, Figure 3 eliminates firm-level scale economies, establishing the restricted VER model.

The KK and HOR models both show an inverted U-shaped curve along the SW-NE diagonal. Type-H MNEs exist between countries with identical relative endowments, and affiliate production is maximized when the countries are identical. (When the countries are very different in size, single-plant type-N firms located in the large country will have the advantage as noted above.) In the VER model, there is essentially no MNE activity along the SW-NE diagonal, and

[3]These results are derived from a computer simulation model develop in Markusen (1997), following the earlier work of Markusen and Venables (1998, 2000) with four firm types (no type-V firms). It uses a complementarity algorithm developed and implemented by Rutherford (1995, 1999). Marginal-revenue, marginal-cost inequalities have outputs per firm as complementary variables, and markup-revenues, fixed-cost inequalities have the numbers of firms active in equilibrium as complementary variables.

no role for country size and size difference independent of relative endowment differences.[4]

Along the NW-SE diagonal (countries differ in relative endowments), the KK and VER models are more similar to each other than to the HOR model. In the latter model, type-H firms become disadvantaged as they must hire costly skilled labor in the skilled-labor scarce country. Vertical firms, on the other hand, are encouraged to enter in both the KK and the VER model as relative endowment differences increase.

There is yet another interesting similarity between the VER and KK models. In both models, there is an interaction effect between country size differences and relative endowment differences. Affiliate activity is maximized when one country is relatively small and skilled-labor abundant. In such a situation, almost all X production is by type-V firms and is affiliate production by definition.

Figures 4-6 show the results in one direction only: production in country f by affiliates of firms headquartered in country h. The reason to consider these one-way results is that it increases the degrees of freedom in the econometric estimation to treat h-to-f and f-to-h as separate observations.

Though there are non-linearities and non-monotonicities in these results, some clear ideas emerge. First, in the KK model in Figure 4 there is a role for total income and size differences independent of relative endowment differences along the SW-NE diagonal. However, there is also a role for relative endowment differences and an interaction between relative endowment differences and size differences. Outward affiliate activity of country h-headquartered firms in country f is highest when h is both small and skilled-labor abundant. One ambiguity in the KK

[4]With reference to an earlier footnote concerning Helpman (1984), we would also get a diagram like Figure 3 if we permitted firm-level scale economies but assumed zero trade costs. The "valley" runs directly along the SW-NE diagonal. Figures 1-3 here make the common assumption that trade costs are "significant".

model occurs with respect to the role of relative endowment differences when country h is skilled-labor abundant. There is a non-monotonic relationship as we move away from the SW-NE diagonal, in which affiliate sales first increase and then decrease. We will refer to this problem below in discussing hypothesized signs of econometric coefficients.

Second, the VER model in Figure 6 permits essentially no role for total income and the size difference between the countries independent of relative endowment differences. If we were to increase the density of endowments (income) in the Edgeworth box in Figure 6, the "wing" on the left would rotate upward (that is, become steeper) with affiliate activity remaining zero on the SW-NE diagonal. Thus the model predicts that affiliate activity increases with total income but only in proportion to relative endowment differences. Size difference between the countries plays no role (except at extreme values).

Third, the HOR model in Figure 5 permits the clearest role for total income and country-size similarity. The maximum point of affiliate activity over the Edgeworth box is not at the center, but occurs when country h is slightly skilled-labor abundant and slightly smaller than country f. However, affiliate activity falls off from the maximum level as the skill-endowment differences and size discrepancies become bigger between the recipient and host countries.

To summarize the simulation results in Figures 4-6, the KK and HOR models predict an important role for total (two-country) income and differences in income independent of relative endowment differences, while the VER model predicts no such independent role. The VER model predicts a role for relative endowment differences, with country h's foreign affiliate activity increasing in its skilled-labor abundance. The KK and VER models predict a negative interaction between skilled-labor abundance and size of the host country, or, to put it another way, a small, skilled-labor abundant nation would likely be the source of considerable VER investment. The

HOR model does not make such a prediction.[5]

3. Data Sources and Variable Construction

To implement the model we define the following variables, which are listed in Table 1, and discuss their construction. The data form a panel of cross-country observations over the period 1986-94. First, we take real sales volume of non-bank manufacturing affiliates in each country to indicate production activity. The U.S. Department of Commerce provides annual data on sales of foreign affiliates of American parent firms and on sales of U.S. affiliates of foreign parent firms. Thus, for each year the United States serves as both the headquarters country for its firms producing abroad and the affiliate country for foreign firms producing there. In the variable listing, subscript i refers to the parent country and subscript j to the host country. There are 36 countries in addition to the US for which we have at least one year of complete data.

Figures for annual sales values abroad are converted into millions of 1990 U.S. dollars using an exchange-rate adjusted local wholesale price index, with exchange rates and price indexes taken from the *International Financial Statistics* (IFS) of the International Monetary Fund.

Real gross domestic product is measured in billions of 1990 U.S. dollars for each country. For this purpose, annual real GDP figures in local currencies were converted into dollars using the market exchange rate. These data are also from the IFS. In Table 1, the variable SUMGDP is the sum of host-country GDP and parent-country GDP, while GDPDIFF is their difference and GDPDIFSQ is their squared difference.

[5]We should also note a difference between the VER model as defined here, and a model with firm-level scale economies and zero trade costs, which would produce a diagram similar to those in Figures 3 and 6. An important distinguishing characteristic between these two cases is that in the latter model (essentially that of Helpman 1984), there is no positive interaction between being small and skilled-labor abundant. The interaction in Figures 3 and 6 is due in large part to the need to locate the single plant in the large country as a consequence of trade costs.

Skilled labor abundance is defined as the sum of occupational categories 0/1 (professional, technical, and kindred workers) and 2 (administrative workers) in employment in each country, divided by total employment. Thus, this abundance measure ranges potentially from zero (very skilled-labor scarce) to one (very skilled-labor abundant). These figures are compiled from annual surveys reported in the *Yearbook of Labor Statistics* published by the International Labor Organization. In cases where some annual figures were missing, the skilled-labor ratios were taken to equal the period averages for each country. The variable SKDIFF is then simply the difference between the relative skill endowment of the parent country and that of the affiliate country. Thus, $SKDIFF = SK_i - SK_j$, is positive if the parent nation is skilled-labor abundant relative to the host nation.

The cost of investing in the affiliate country, indicated as INVCJ, is a simple average of several indexes of impediments to investment throughout the period, reported in the *World Competitiveness Report* of the World Economic Forum. The indexes include restrictions on the ability to acquire control in a domestic company, limitations on the ability to employ foreign skilled labor, restraints on negotiating joint ventures, strict controls on hiring and firing practices, market dominance by a small number of enterprises, an absence of fair administration of justice, difficulties in acquiring local bank credit, restrictions on access to local and foreign capital markets, and inadequate protection of intellectual property. These indexes are computed on a scale from 0 to 100, with a higher number indicating higher investment costs. A trade cost index is taken from the same source and is defined as a measure of national protectionism, or efforts to prevent importation of competitive products. It also runs from 0 to 100, with 100 being the highest trade costs. All of these indexes are based on extensive surveys of multinational enterprises. In the model, trade costs in both host and parent countries are relevant, motivating us to define both TCJ and TCI.

Using these fundamental variables, we generate a number of constructed versions and interaction terms to capture elements of the theory. Predictions from the three models are indicated in the top part of Table 1. For this purpose, predictions of a positive relationship are given by "+", of a negative relationship by "-", and of no relation by "0". This framework establishes the nesting procedure we use. That is, because the KK model incorporates all of the variables listed, it is the unrestricted model. The HOR model differs by exclusion from its estimation of the interaction term D2*SKDGDPD, defined below. Finally, the VER model excludes SUMGDP and GDPDIFSQ.

The first two variables, SUMGDP and GDPDIFSQ capture the inverted U-shaped relationship along the SW-NE diagonal of the Edgeworth box in Figures 4-6. The coefficient on SUMGDP is predicted to be positive and that on GDPDIFSQ to be negative for the KK and HOR models. However, we predict it to be zero in the VER model for, as noted earlier, economic size and size differences have no role in the VER model independent of factor-endowment differences.

The dummy variables D1 and D2 are designed to capture the fact that our simulation predictions depend on whether the parent country is the skilled-labor abundant or skilled-labor scarce country. Variable D1 takes the value negative one if the parent is skilled-labor *scarce* and D2 takes the value positive one if the parent is skilled-labor *abundant* relative to the host.

In this regard, the complicated variable D2*SKDGDPD, which is the product of D2, SKDIFF, and GDPDIFF, is designed to capture the interaction between being skilled-labor abundant and small that we discussed in connection with the KK model. The coefficient on this variable is predicted to have a negative sign in the KK and VER specifications (i.e., being small and skilled-labor abundant increases outward investment), but to be zero in the HOR model.

The variable D2*SKDSUMG is the product of D2, SKDIFF, and SUMGDP. Thus, it is an interaction term between factor abundance and the total size of the "world" economy. This term is

positive if the parent is skilled-labor abundant and zero otherwise. This is a fundamental variable in the VER model, as shown in Figure 6. For a given SUMGDP, outward investment increases in the parent country's skilled-labor abundance, and for a given SKDIFF, outward investment increases in total GDP. Thus, the coefficient on this variable should have a positive sign in the VER model. However, its sign would be negative in the HOR model (see Figure 5). In principle, the sign is ambiguous in the KK model. On the one hand, an increase in total world income would raise affiliate activity when the countries are similar and when the parent country is skilled-labor abundant. On the other hand, income growth among countries with similar relative endowments should produce conversion from national firms to horizontal firms. In this context, income growth should have a proportionately larger effect when the countries are similar. We therefore hypothesize that this interaction variable is negative in the KK model as well as in the HOR model.

The term D1*SKDSUMG is the product of D1, SKDIFF, and SUMGDP. It is positive if the parent country is skilled-labor scarce. The coefficients on this term are hypothesized to be negative in all three models. Outward investment activity should fall as the parent country becomes increasingly scarce in skilled labor. Indeed, our simulations suggest that if the parent country is skilled-labor scarce the level of outward FDI should be small in absolute terms.

The first horizontal line in Figure 1 divides the variables of interest in the theory (above the line) from a set of common control variables that are expected to have the same signs in all equations (below the line).

The first control variable is distance. Theory does not give a clear prediction as to the direction of its impact, since distance increases the costs of both trade (suggesting a substitution toward investment) and investment (suggesting a reduction in FDI). The second variable is the host-country's investment cost index. Because higher numbers indicate higher costs, this variable is predicted to affect FDI activity negatively in all three regressions. The term TCJ is the

host-country's trade cost index and its coefficients are expected to be positive because higher trade barriers encourage inward investment. Finally, TCI is the parent-country's trade cost index, with coefficients that are expected to be negative. Higher values of TCI raise the costs of shipping goods back to the parent from a branch plant, although this should not be important in the case of outward horizontal investment.

4. Results

We present the estimation results in Tables 2-5. In all cases, the dependent variable is production in country j by affiliates of country i parents. Variables listed as zeroes in Table 1 are omitted from the regressions.

Tables 2 and 3 use only distance among the control variables. An initial econometric concern is heteroskedasticity across observations because country sizes are quite different. Thus, we employ in Table 2 a weighted least-squares (WLS) estimation, where the weights are developed from regressions of first-stage ordinary least squares residuals on linear functions of SUMGDP or square roots of such linear functions. In the WLS regressions we exclude cases where data on local sales are missing, yielding 509 observations. The first pair of columns in Table 2 contain results for the WLS version of the unrestricted KK model. This model explains 60 percent of the variation in weighted sales, and all of the coefficients are highly significant, with the expected signs, except that of D2SKDGDPD, which is not significant.

As may be seen from the second pair of columns, restricting the coefficient on D2SKDGDPD to be zero in the HOR model results in no decline in the adjusted R^2. The remaining coefficients in HOR are close to those in KK. Indeed, the F-test in HOR cannot reject the zero restriction on D2SKDGDPD, as shown at the bottom of the table. The negative sign on this F-test stems from the fact that the dependent variables in the two WLS specifications bear

different weights, so that the nesting procedure is not, strictly speaking, correct. As indicated in the penultimate row, however, an F-test on the underlying OLS regressions cannot reject HOR relative to KK. In statistical terms, these models are indistinguishable.

The VER model has the right signs on all coefficients, but much lower explanatory power than the KK and HOR models. It is decisively rejected by the F-test for zero restrictions on SUMGDP and GDPDIFSQ. Indeed, much of the influence of total two-country income is picked up in the intercept, which is large and positive, unlike those in the other regressions. Thus, the VER model, in which economic size and size differences play no independent role in explaining multinational activity, fails to accord with the data.

In our data sample there are a number of missing observations on local affiliate sales. On inspection these involve potential parent countries that are small and poor and have likely not invested in the United States. Therefore a reasonable assumption is that these missing values are, in fact, zeroes. In Table 3 we include these observations with a zero for affiliate production and estimate a Tobit equation on the resulting 722 observations.

These results complement the WLS findings. Note that the Tobit coefficients on all variables involving skill differences are considerably larger in magnitude than their WLS counterparts, stemming from the inclusion of more observations from developing nations. Again, in the KK model the coefficient on D2SKDGDPD takes the wrong sign and in this case is marginally significant. The likelihood ratio test cannot reject the zero restriction on this variable in the HOR model, again suggesting that KK and HOR are indistinguishable. Finally, note that while the coefficients are correctly signed and significant in VER, implying that skill differences matter importantly for FDI, the model itself is decisively rejected in relation to KK and HOR.

Tables 4 and 5 repeat the analysis, using all the control variables. The coefficients on INVCJ are always significant and have the right sign. Interestingly, those on TCJ are positive and

significant in the WLS specifications but fall in magnitude and lose significance in the Tobit equations for KK and HOR. On that score, it seems that trade protection loses its attractiveness to FDI in small developing nations in comparison with its effect in developed countries, except in the VER framework. The coefficients on TCI always have the right signs as well, although they are generally insignificant.

In terms of the nested testing, results in Tables 4 and 5 are consistent with earlier findings. The HOR model is strongly supported in the WLS regressions in terms of signs and significance of coefficients and its specification cannot be rejected relative to the KK model at the 99% confidence level. It would be rejected at the 95% level using the WLS result but would not be so rejected using the OLS F-test. Note, however, that the restriction in HOR is rejected in the Tobit regression in Table 4. It seems that entering investment costs in the sample that includes more observations from developing countries reduces somewhat the explanatory power of the HOR model relative to KK.

The coefficients have the right signs and strong statistical significance in the VER regressions in Tables 4 and 5, but the zero restrictions of the model are rejected. Note again the reversal in the sign of the intercept term in the VER regression relative to the other two, suggesting that the independent influence of income is being absorbed into the intercept.

5. Summary

Our econometric results support the KK and HOR models, finding them to be essentially indistinguishable in the data but considerably more descriptive of reality than the VER model in explaining overall world multinational activity. The coefficient estimates in the HOR model have the right signs and are statistically significant, as they are in the KK model with one exception.

These results support what researchers have long believed from casual empiricism. In

particular, direct investment is important between countries that are similar both in size and in relative endowments. It is the "hill" of Figure 2, rather than the "valley" of Figures 3, that best describes the world. The VER model clearly should not be taken seriously as a characterization of aggregate multinational activity.

The comparison between the unrestriced KK model and the restricted HOR model is less straightforward. The restriction of the HOR model may be rejected at the 95% level when the control variables are included but overall there is little in the data to distinguish the two models. In this sample, therefore, there do not seem to be strong effects on affiliate sales stemming from the interaction between skilled-labor abundance differences and size differences.

Such impacts are predicted by the KK model and were detected in Carr, Markusen and Maskus (2001). The data are the same in the two papers, but the estimating equations are different. CMM (2001) used what we consider to be our "ideal" regression equation to estimate the model, without considering an explicit alternative model. In particular, SKDIFF was used as a variable by itself and not interacted with SUMGDP. All the central coefficients had the right sign and were highly significant, indicating an important role for differences in skilled-labor abundance. In the present paper, some compromises to this "ideal" regression equation were made in order to nest the models.[6]

Possibly more relevant, the effect of an increase in SKDIFF is complicated because SKDIFF appears in two regressors in the KK model. Using the mean values of GDPDIFF and SUMGDP (which vary with the number of observations), the partial derivatives of the four

[6]If the effect of increased total income is to "lift up" the whole surface in Figure 1 (i.e., the effect of an increase in SUMGDP does not depend on SKDIFF), then the specification in CMM is preferred for estimating the KK model over the present formulation. But it is clear that SKDIFF and GDPDIFF should be interacted for the VER model (the effect of an increase in SUMGDP is proportional to SKDIFF), so we use that variable here for the KK model as well.

equations for the KK model with respect to SKDIFF are positive for the two Tobit regressions, but negative for the two WLS regressions. For US outward investments (where GDPDIFF is large and positive), an increase in SKDIFF always increases outward affiliate production. Thus, the results on the KK model are not as clear as they seem from looking at individual coefficients alone and a positive role for SKDIFF is not rejected here. The interested reader is referred to CMM for a more detailed treatment of the KK model.[7]

We interpret the results as providing strong support to the KK model, but not permitting us to distinguish it in aggregate data from the HOR model. A principal message is that the VER model is a poor characterization of the overall pattern of world FDI activity, a finding consistent with the results in Brainard (1993, 1997). As noted in the introduction, vertical activities may be important to some host economies in some industries. But in a horse race to pick one model to explain aggregate activity, the VER model loses to the HOR and KK models.

[7]Also, Markusen and Maskus (1999) find support for the KK model by breaking down affiliate production into that portion sold in the host country and that portion exported back to the parent country.

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